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PRELIMINARY REPORT ON SAMPLING OF FISH LIVERS

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One of the striking features of the liver-oil industry is the practice of buying and selling livers without a definite knowledge of their value. This practice has persisted in spite of the fact that the vitamin A content is known to vary by several hundred percent. Such a practice would be inconceivable in almost any other industry in which the price of the raw material is as high (up to $6.00 per pound or more) as that of fish livers.

In order to provide knowledge as to the value of the livers at the time of sale, a rapid, convenient method of obtaining a representative sample of the livers must be available and a quick test for the oil and its vitamin A potency is required. The Seattle laboratory has begun a study of the problem, and attention has been devoted first to the technique of obtaining a representative liver sample for analysis. This problem is complicated by the following five factors:

1. Variation of vitamin A and oil concentration from one part of the liver to another.
2. Variation of vitamin A potency from liver to liver.
3. The frequent presence of a layer of free oil on the top of the container as a result of the separation of oil from the liver.
4. Presence of adulterants such as salt, parts of viscera, or livers of extraneous species.
5. "Stovepiping" or manipulation of the liver material in such a way as to increase the probability that a sample will be taken higher in vitamin A than the average for the material being sampled.

Brocklesby and Rogers1/ have shown that the vitamin A potency of liver oil may vary from one section of the liver to another. In the case of dogfish they found that the lowest oil content and the highest oil potency occurred in that portion of the liver nearest the ducts; whereas, with lingcod and halibut, the reverse was found to be true.

Some indication of the magnitude of the change in potency from one portion of the liver to another can be obtained from the data shown in Table 1 on two individual dogfish livers examined in this laboratory. In analyzing liver No. 1 each of the two lobes was cut into three large sections and each section analyzed separately. In the analysis of liver No. 2, small pieces were cut from the tip, center, and duct sections of one of the lobes and analyzed separately as was also the portion of this one lobe remaining after the three small pieces had been cut from it.

These data indicate that there may be appreciable differences in potency from one section of the liver to another, even when large portions are taken, and that the differences

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1/ H. N. Brocklesby and N. I. Rogers, Progress Report No. 50, Pacific Stations, Fisheries Research Board of Canada (1941).

Note: This leaflet supersedes Sep. 87, a reprint from Fishery Market News, January 1945, pages 2-5.

Table 1 - Differences in Vitamin A Potency in Oil from Various Sections of Dogfish

Item	LIVER		OIL	
	Section sampled	Weight of sample	Content	Vitamin A
		Grams	Percent	U.S.P. Units Per Gram
Liver No. 1 (each lobe cut into three pieces)	Tip lobe a	142	78	13,300
	Tip lobe b	184	78	13,500
	Center lobe a	167	79	13,500
	Center lobe b	199	79	14,100
	Duct section lobe a	114	75	15,600
	Duct section lobe b	154	70	16,900
Liver No. 2 (three pieces from one lobe and the remainder of the lobe)	Tip	4	61*	17,900
	Center	7	52*	16,200
	Duct	7	48*	34,900
	Remainder of lobe	360	68	18,800

*Oil incompletely extracted.

may become greater as the size of the portion decreases. This variation from one part of the liver to another is a source of error in those methods of sampling in which a drill is employed or in which small sections are clipped from each liver.

Table 2 - Differences in Oil Content and Vitamin A Potency of Livers from Dogfish (Squalus suckleyi) Caught in Waters of Puget Sound during January 1943

LIVERS FROM MALES			LIVERS FROM FEMALES		
	Vitamin A			Vitamin A	
Oil Content	Per Gram of Oil	Per lb. of Liver	Oil Content	Per Gram of Oil	Per lb. of Liver
Percent	U.S.P. Units	Millions of U.S.P. Units	Percent	U.S.P. Units	Millions of U.S.P. Units
66	17,100	5.1	76	22,300	7.7
69	13,400	4.2	80	12,000	4.4
68	4,100	1.27	80	6,400	2.32
69	12,500	3.9	76	21,800	7.5
54	5,300	1.30	76	6,400	2.20
45	4,500	0.92	77	9,700	3.4
60	2,200	0.60	64	27,000	7.8
			75	7,100	2.42
			70	4,500	1.43
			62	4,500	1.27
			57	1,200	0.31
			51	9,700	2.25
			64	900	0.26

Tables 2 and 3 show the differences in potency and oil content which are encountered in individual dogfish and soupfin shark livers. The variation in potency from one liver to another is of enormous magnitude. This variation from liver to liver does not appear

Table 3 - The Accuracy of the Clip Sampling Method as Applied to Individual, Male, Soupfin-shark Livers (Galeorhinus zyopterus)

Sample No.	ANALYSIS ON WHOLE LIVER			ANALYSIS ON CLIP SAMPLE			PERCENTAGE DEVIATION OF CLIP SAMPLE FROM WHOLE LIVER		
		Vitamin A			Vitamin A			Vitamin A	
	Oil in Liver	Per Gram of Oil	Per lb. of Liver	Oil in Liver	Per Gram of Oil	Per lb. of Liver	Oil in Liver	Per Gram of Oil	Per lb. of Liver
	%	Thousands of U.S.P. Units	Millions of U.S.P. Units	%	Thousands of U.S.P. Units	Millions of U.S.P. Units			
1	65.2	74	21.9	64.3	70	20.4	-1.38	-5.40	-6.85
2	60.4	162	44.4	60.8	159	43.9	+0.66	-1.85	-1.13
3	57.7	157	41.2	58.7	167	44.5	+1.73	+6.37	+8.00
4	56.4	134	34.3	57.5	130	33.9	+1.95	-2.97	-1.17
5	60.5	130	35.7	62.7	130	37.0	+3.64	0.00	+3.64
6	63.4	147	42.3	64.6	148	43.4	+1.89	+0.68	+2.60
7	63.5	164	47.3	58.9	168	45.0	-7.25	+2.44	-4.86
8	60.3	155	42.4	57.2	153	39.8	-5.14	-1.29	-6.14
9	58.3	162	42.9	59.5	164	44.3	+2.05	+1.23	+3.26
10	67.4	132	40.4	68.2	127	39.4	+1.18	-3.77	-2.48
11	64.0	144	41.9	64.5	145	42.5	+0.78	+0.70	+1.43
12	52.7	203	48.6	51.5	205	48.0	-2.28	+0.98	-1.23
13	66.8	114	34.6	64.7	121	35.5	-3.15	+6.44	+2.60
				MEAN- - - - - - - - - - -			+0.41	+0.25	-0.18
				Standard deviation- - - - - -			3.22	3.47	4.30
				Standard error of the mean- - -			0.93	0.96	1.19

to have received the attention in liver sampling which is required if representative samples are to be obtained. As a consequence of this wide variation, even if livers are received in the most perfect condition, the sampling of livers is still a difficult problem.

After the livers have stood for a period of time at temperatures above that at which they would be frozen, liver-oil separates forming a layer of free oil on the top of the container. This separation occurs even more rapidly after the livers have been frozen and subsequently thawed.

Another problem which causes concern is the presence among the livers of such foreign material as viscera, livers of an extraneous species, and salt. It has been found by the industry that in those cases where salt was used as a preservative, as much as 15 percent or more of the total weight was accounted for by the salt. Thus, to obtain a sample representative of the liver material, the salt content would have to be determined first. When in addition to the heterogeneity of the liver material itself, there is an accumulation of free oil and salt, it is evident that the problem of liver sampling becomes extremely complex.

"Stovepiping" or manipulation of the livers in such a way as to give a sample which is not truly representative is sometimes encountered. "Stovepiping" got its name from the practice of putting a stovepipe in the center of the container and then filling in the sides of the container with low potency material and adding high potency material to the stovepipe. When the pipe was removed, the center of the can then contained all the high potency material. Any sample which was then taken by a thief being plunged down the center of the container, as was the common practice, would then, of course, be biased.

In the preliminary work carried out thus far in the Seattle Laboratory, four methods of sampling have been briefly studied. The first of these was visual inspection in which the vitamin A content is estimated by a consideration of size and color of the livers. This is the easiest, quickest, but least accurate method. It has one important advantage in that the livers can be appraised without altering them in any way. However, the method requires experienced personnel and even then errors as great as 100 percent are occasionally encountered.

A second method considered was that of clip sampling, which consists of clipping several small pieces from each liver; this can be done in a number of ways, perhaps the simplest and most convenient of which is to cut, with a sharp knife, one or more small (about 2/3 ounces) "V" shaped pieces from each liver.

In connection with an earlier investigation into factors affecting the potency of soupfin shark livers, an attempt was made to develop a method for sampling individual livers as the costs involved in buying the whole liver was prohibitive. Incidental to this work, the data presented in Table 3 were accumulated. This gives the accuracy of the clip sampling method as applied to individual male soupfin shark livers. In obtaining the clip samples, three pieces were cut from the edge of each of the two lobes, one from the tip, one from the center, and one from the duct section; thus, there were six pieces cut from each liver. These were disintegrated and homogenized in a blender to constitute the clip sample. The liver remaining after the clip sample had been taken was ground through a meat chopper and stirred to uniformity. A generous portion of this ground material was then homogenized further in a blender to form the sample for the whole liver. As can be seen from the data, the method is quite reliable, having an error of about 3 percent.

Table 4 - The Accuracy of the Clip Sampling Method When One Piece is Cut from the Central Section of each Lobe of each Soupfin-shark Liver in a 5-gallon Can

	ANALYSIS ON WHOLE LIVER			ANALYSIS ON CLIP SAMPLE			PERCENTAGE DEVIATION OF CLIP SAMPLE FROM WHOLE LIVER		
		Vitamin A			Vitamin A			Vitamin A	
Can No.	Oil in Liver	Per Gram of Oil	Per lb. of Liver	Oil in Liver	Per Gram of Oil	Per lb. of Liver	Oil in Liver	Per Gram of Oil	Per lb. of Liver
	%	Thousands of U.S.P.Units	Millions of U.S.P.Units	%	Thousands of U.S.P.Units	Millions of U.S.P.Units			
1	55.4	160	40.6	59.9	134	36.5	+8.1	-16.2	-12.2
2	57.4	147	39.0	59.5	132	36.0	+3.7	-10.2	- 7.7
3	55.4	146	37.1	57.2	138	35.7	+3.2	- 5.5	- 2.7
					Average error- - - - - - - -		5.0	10.6	7.5

In an investigation into the variability of potency from liver to liver, the clip sample would be of value; however, it is too slow and laborious to be widely useful in commercial practice. This objection would be lessened if the number of pieces cut from each liver were reduced. Table 4 gives the accuracy of the method in sampling soupfin shark livers in five-gallon cans when one piece is cut from the edge of a central section of each lobe of each liver in the can. These pieces, comprising about eight ounces by volume were ground and homogenized to form the clip sample. The liver remaining in the can was then ground through a meat chopper and this ground material stirred to homogeneity. A portion, which was further disintegrated in a blender, formed the ground sample. Preliminary experimentation has shown that a ground sample taken in this manner gives duplicate samples which agreed within the error of the vitamin A analysis (better than 2 percent). Therefore, any deviation from the ground sample can be considered as being in error. Even after the number of pieces cut from each liver had been reduced from six to two, the method was still tedious, and as can be seen from the data, not very accurate.

A third method of sampling is the use of an electrically-operated sampling device. This device consists of a long auger bit rotated by an electric drill motor inside a closely fitting metal tube such that the liver material is forced up the tube and out an opening in the top into a sampling bottle. A few thrusts of this device into a can of livers gives the sample.[1/] While studies on this device are incomplete, the data so far accumulated indicate that a predetermined precision of 95 percent or better can be obtained, depending upon the size of the lot and the number of cores taken. Experimentation now in progress to determine the accuracy of the device indicates that there is no bias in the samples. It must be emphasized, however, that this statement is based upon only a few data and requires verification by further work.

A fourth method of sampling consists of grinding the entire amount of liver and mixing thoroughly. As indicated above, this method gives as homogeneous a sample as can be obtained and the results found by this method can be considered to be the most accurate provided the material has been truly homogenized.

Table 5 - Comparison of the Various Methods of Sampling Discussed in this Report

Method	Speed	Error of method	Disadvantages	Advantages
Visual estimation	Rapid	Large, 0-100%	Not accurate. Requires experience and judgment.	Does not change livers in any way.
Clip sampling	Slow	Intermediate, 0-15%	Slow and laborious.	Does not require power nor special apparatus.
Drill sampling	Rapid	Intermediate, probably 0-5%	Source of electric power required. Method gives reduced accuracy for very small lots of livers and may not be applicable where there is salt or free oil.	A large amount of livers can be sampled rapidly. Sampler is inexpensive and easily transported.
Liver disintegration	Rapid	Small	Disintegrated livers are less acceptable for resale. Oil may be less stable as result of air being mixed with livers. Machine is expensive and not easily transported. Source of power required.	The most precise method of sampling. Almost any type of liver, fresh, salted, mixed, or decomposed can be sampled.

Table 5 compares the four sampling methods. No one method is universally applicable, one being better than another under certain conditions. Evidently the most accurate of the methods studied is that of total disintegration. However, when a disintegrator is not available, or where, for other reasons, its use seems inadvisable, either the electrically-operated drill sampler or the clip sampling method will give results of sufficient accuracy for most purposes. The sampling drill is much more convenient and rapid and is recommended in preference to clip sampling wherever this device can be obtained and where the necessary power for its operation is available.

Further tests of these and other sampling methods are contemplated, and work is in progress on the development of a rapid method for determining the vitamin A and oil content of liver samples.

1/ "Preliminary Report on a Drill Sampling Device for Fish Livers," by Charles F. Shookey and F. Bruce Sanford, Fishery Market News, May 1944, pp. 9 and 10.
"Drill Sampling Device for Fish Livers I. Constructional Details," by L. G. McKee, F. B. Sanford, and G. C. Bucher, Fishery Market News, November 1944, pp. 6 - 9.
"Drill Sampling Device for Fish Livers II. Instructions for Use," by F. Bruce Sanford, G. C. Bucher, and Maurice E. Stansby, Fishery Market News, November 1944, pp. 9 - 11.

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